PART 4

LM2-TOXIC

Chapter 2. Recommendations

LM2-Toxic was developed for its efficient conduct of model calibrations and its capability to forecast long-term impacts resulting from a variety of control actions applied to an aquatic system. There are still quite a few improvements that can be done to enhance the credibility of the model predictions. The recommendations for the further improvements and tests are listed below.

1. The results from the long-term cesium hindcast simulation should not be limited to comparison to the water column concentration and total sediment cesium inventory. They should include comparisons with the available ^{137}Cs sediment core profiles. This will provide an additional confirmation on the solid vertical transport dynamics (settling, resuspension, and burial rates) in Lake Michigan.

2. Instead of the empirical approach to estimate sediment resuspension of each sediment segment, a more sophisticated mechanistic sediment transport model (e.g., SEDZL or SEDZLJ), should be used to provide a more accurate and realistic sediment resuspension.

3. Model verification (a post-audit) should continue using the latest field data collected around Lake Michigan to verify 1) parameters and rates used in the model and 2) some of the conclusions made from the long-term forecast scenarios.

4. As an extended confirmation process, 1) comparison between net settling fluxes of organic carbon generated from the model with available sediment trap data, and 2) more research conducted on carbon:chlorophyll *a* ratio including its spatial variation in the lake are needed.

5. To investigate the potential impacts on the outcomes of the model by critical environmental processes and under different physical, chemical, and meteorological conditions, more systematic analyses are needed, including:

   A. Sensitivity analysis of the fluxes across the air-water interface by using different gas and liquid transfer formulations.

   B. Sensitivity analysis of model responses by changing surficial sediment initial conditions.

   C. Investigation of model responses in both water column and sediment to various mass fluxes across the sediment-water interface by changing diffusion coefficient and/or mixing length between the water column and surficial sediment.

   D. Investigation of potential impacts of ice-cover and water surface elevation on the model outcome.

   E. Investigation of the impacts of carbon internal loads on the results of LM2-Toxic PCB hindcast.

   F. Investigation of system responses to different hydrodynamic transport fields.

G. Sensitivity analysis of organic carbon decay rates in the surficial sediment.

All of the above analyses should be conducted on both short-term and long-term scales to see the short-term and long-term effects on the model simulation results.

6. Explore the effect of a huge resuspension event on outcomes of the model hindcast and forecast.

7. Addition of a benthic nepheloid layer (BNL) to the model configuration to address the importance, effects, and benefits of this compartment on the overall organic carbon and hydrophobic organic chemicals cycling in the lake system.

8. Expand the model to more applications and additional contaminants including a) mercury and *trans*-nonachlor modeling for Lake Michigan and b) finer model resolutions (e.g., Level 3) in both spatial and kinetic processes.

9. Couple an air model to the LM2-Toxic to compute vapor phase concentration dynamically for more accurate calculation of the fluxes across the interface between air and water.

10. Collect a higher density of sediment samples from shallow high-energy areas of Lake Michigan that will greatly enhance the representativeness of carbon sorbent or toxic chemical dynamics in these zones. These may significantly influence sediment-water exchange and toxic chemical dynamics in Lake Michigan.

11. Apply a different segmentation (still similar to the spatial resolution as the current segmentation used in LM2-Toxic) to the model to 1) more efficiently utilize nearshore and offshore data, 2) document nearshore and offshore gradients observed in the data collected for the Lake Michigan Mass Balance Project (LMMBP) for most congeners, and 3) investigate the impacts of using different segmentations (even on the same spatial resolution) on the model outcomes.

12. Conduct sensitivity analysis on potential polychlorinated biphenyl (PCB) decay rates in both water column and sediments of Lake Michigan. The model currently assumes no PCB decay in both compartments.

13. Investigate the uncertainty associated with the selected parameters for specific processes conceptualized in the LM2-Toxic using Monte Carlo or other uncertainty analyses.

Considering the feasibility of these recommendations, they can be categorized as follows:

A. The recommendations that can be done in a relatively short time period with limited effort include Numbers 5A, B, C, G; and 12.

B. The recommendations that can be done within a relatively moderate time frame and effort once the necessary data are available include Numbers 3; 4; 5D, E, F; and 6.

C. The recommendations that can be done in a long time frame and significant effort include Numbers 1, 2, 8, and 13.

D. The recommendations that can be done in a very long time period and demand full effort include Numbers 7, 9, 10, and 11.